CHAPTER 2: ANALYTICAL FRAMEWORK

In prescribing new or amended energy efficiency appliance standards, the Department must achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. This chapter provides a description of the general analytical framework used by the Department in developing standards and assessing the impacts for all products. This chapter also provides a description of those aspects of the framework specific to central air conditioners and heat pumps. The analytic framework essentially is a description of the methodology, the analytical tools, and the relationship between the various analyses conducted as part of a rulemaking. A diagram of the general analytical framework is shown in Figure 2.1.

The analyses performed in the general analytic framework include:

- A Preliminary Market and Technology Assessment to characterize the relevant product markets and existing technology options including prototype designs. (Subtask 1 in Fig. 2.1)
- A Screening Analysis to review each technology option and determine if it is practicable to manufacture, install and service, would adversely impact product utility or product availability, or would have adverse impacts on health and safety. (Subtask 2 in Fig. 2.1)
- An Engineering Analysis to determine the maximum technologically feasible energy efficiency level and to develop cost-efficiency relationships that show the manufacturer's cost of achieving increased efficiency. (Subtask 3 in Fig. 2.1)
- A Life-Cycle Cost and Payback Period Analysis to calculate, at the consumer level, the discounted savings in operating costs (less maintenance and repair costs) throughout the estimated average life of the covered product compared to any increase in the installed cost for the product likely to result directly from the imposition of the standard. (Subtask 5 in Fig. 2.1)
- A National Impacts Analysis to assess the aggregate impacts at the national level of consumer payback, net present value (NPV) of total consumer life-cycle cost, national energy savings, and national employment. (Subtask 8 in Fig. 2.1)
- A Consumer Analysis to evaluate variations in household characteristics (e.g., energy prices, appliance use behavior, installation costs) that might cause a standard to impact particular consumer sub-populations, in particular low-income households, differently than the overall population. (Subtask 10 in Fig. 2.1)
- A Manufacturer Impact Analysis (MIA) to estimate the financial impact of standards on manufacturers and to calculate impacts on competition, employment, and manufacturing capacity. (Subtask 11 in Fig. 2.1)
- A Utility Analysis to estimate the effects of proposed standards on electric utilities. (Subtask 12 in Fig. 2.1)
- An Environmental Analysis to provide estimates of changes in emissions of pollutants (sulfur and nitrogen oxides and carbon dioxide). (Subtask 13 in Fig. 2.1)
- A Regulatory Impact Analysis to present major alternatives to proposed standards that could achieve substantially the same regulatory goal at a lower cost. (Subtask 14 in Fig. 2.1)

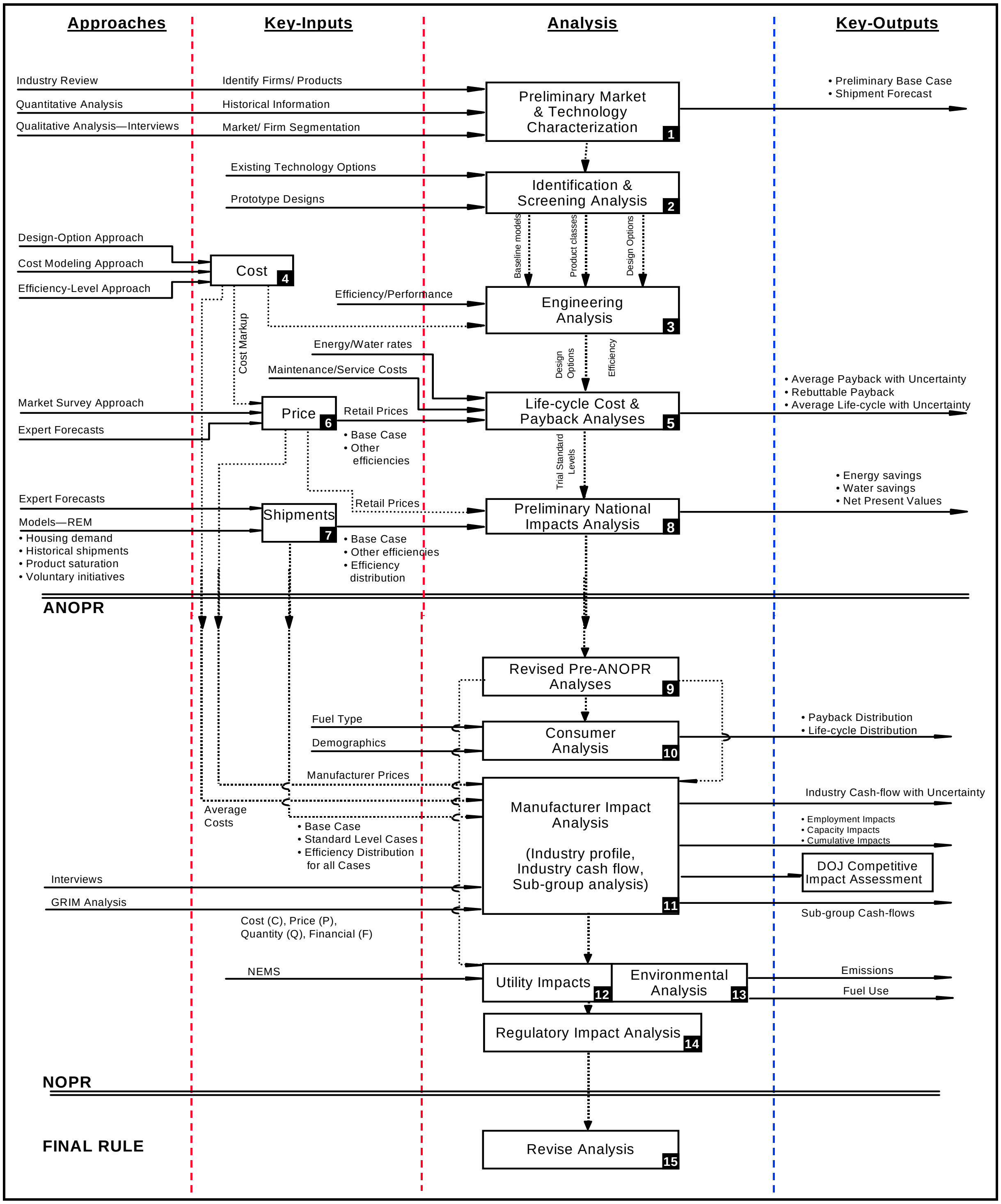

Figure 2.1 Central Air Conditioner and Heat Pump Rulemaking Framework

2.1 BACKGROUND

As described in Chapter 1, in September, 1995, the Department announced a formal effort to consider further improvements to the process used to develop appliance efficiency standards; calling on energy efficiency groups, manufacturers, trade associations, state agencies, utilities and other interested parties to provide input to guide the Department. On July 15, 1996, the Department published a Final Rule: Procedures for Consideration of New or Revised Energy Conservation Standards for Consumer Products (hereinafter referred to as the Process Rule). 61 FR 36974. The Process Rule outlined the procedural improvements identified by the interested parties. The process improvement effort also included a review of the: 1) economic models; 2) analytical tools; 3) methodologies; 4) non-regulatory approaches; and 5) prioritization of future rules. The Department will also take into account uncertainty and variability by doing scenario or probability analysis. A detailed discussion of variability and uncertainty is provided in Appendix A.

The Department developed the analytical framework for the central air conditioner and heat pump rulemaking in response to stakeholder concerns regarding the application of the Process Rule. This analytical framework was presented during a central air conditioner and heat pump workshop held on June 30, 1998. The following sections provide a general description of the different analytical components of the rulemaking framework.

2.2 PRELIMINARY MARKET AND TECHNOLOGY ASSESSMENT

A preliminary market and technology assessment characterizing the relevant product markets and existing technology options including prototype designs was conducted for the Supplemental ANOPR. Although a market and technology assessment was not developed for the Supplemental ANOPR on central air conditioners and heat pumps, elements of the assessment were conducted. Those elements are discussed in this TSD.

2.2.1 Market Assessment

When initiating a standards rulemaking, the Department develops information on the present and past industry structure and market characteristics of the product(s) concerned. This activity consists of both quantitative and qualitative efforts to assess the industry and products based on publicly available information. Issues to be addressed include: 1) manufacturer market share and characteristics; 2) trends in the number of firms; 3) the financial situation of manufacturers; 4) existing non-regulatory efficiency improvement initiatives; and 5) trends in product characteristics and retail markets. The information collected serves as resource material to be used throughout the rulemaking.

Manufacturer market share and characteristics of the central air conditioner and heat pump market are outlined in Chapter 4.3, *Distribution Markups*. As discussed in that section, roughly two dozen equipment manufacturers, several hundred distributors, and more than 30,000 dealers operate in the United States. Due to a wave of consolidation over the last 15 years, the top seven manufacturers control 97 percent of the market. Most remaining manufacturers produce such products as indoor coils or niche product lines. For more details on trends in the retail market, refer to Section 4.3.

2.2.2 Technology Assessment

Information relative to existing technology options and prototype designs are used as inputs to the screening analysis. In consultation with interested parties, the Department develops a list of design options for consideration. All technologically feasible design options are candidates in this initial assessment.

As described in Chapter 4.3, commonly utilized technologies that improve the efficiency of central air conditioners and heat pumps include: 1) increased coil face areas and depth, 2) multiple speed fan motors or blower motors, 3) variable (or multiple) speed or capacity compressors or dual compressors, 4) thermostatic or electronic expansion valves, 5) improved air flow and fan designs, and 6) increased efficiency compressors (scroll, advanced reciprocating).

As described in Chapter 4.5, several emerging technologies were reviewed and analyzed for central air conditioners and heat pumps. These included advanced variable speed controls, microchannel heat exchangers, and advanced compressors. Although these emerging technologies were not considered to be commercially available, their potential impact on reducing the cost of 3-ton split system air conditioners were analyzed.

2.2.3 Preliminary Base Case Shipments Forecast

The Department developed a base case forecast of product shipments in the absence of new standards for the Supplemental ANOPR. This forecast was revised and updated for this TSD. The forecast includes an assessment of the impacts of past and existing non-regulatory efforts by manufacturers, utilities and other interested parties. DOE considers information on the actual impacts of such initiatives to date, and also considers information presented regarding the possible impacts that any existing initiatives might have in the future. Such information could include a demonstration of the steps manufacturers, distribution channels, utilities or others will take to realize such voluntary efficiency improvements.

The base case shipments forecast is used as input to the national impacts analysis, in which a forecast of annual shipments and their weighted average energy efficiency is needed to the year 2030. The base case shipments forecast for central air conditioners and heat pumps is detailed in Chapter 6.

2.3 SCREENING ANALYSIS

The screening analysis reviews various technologies with regard to whether they: a) are technologically feasible; b) are impracticable to manufacture, install and service; c) have an adverse impact on product utility or product availability; and d) have adverse impacts on health and safety. The screening analysis establishes product classes, baseline units, and efficiency levels (or combinations of design options) for further analysis. Chapter 3 provides an overview on the screening of design options for central air conditioners and heat pumps while Chapter 4 provides a discussion on product classes and baseline equipment.

2.3.1 Product Classes

Product types are divided into classes using the following criteria: a) the type of energy used; b) capacity; and c) performance-related features that affect consumer utility or efficiency. Different energy efficiency standards will apply to different product classes. In general, classes are defined using information obtained in discussions with appliance manufacturers, trade associations, and other interested parties.

In this TSD the following four product classes are analyzed: 1) split system air conditioners, 2) split system heat pumps, 3) single package air conditioners, and 4) single package heat pumps. Chapter 4.6, *Product Classifications*, discusses other product classifications for central air conditioners and heat pumps.

2.3.2 Baseline Equipment

In order to analyze design options for energy efficiency improvements, the Department defines a baseline unit. For each product class, the assumed baseline unit is a product that meets the existing standard. For central air conditioners and heat pumps, such baseline equipment are typically “lower-cost” units that contain no premium features, e.g., noise reduction, service, or appearance features. To determine the characteristics of the baseline unit in this screening analysis, the Department gathers information from trade organizations, manufacturers, and consultants with expertise in specific product types. A description of baseline central air conditioners and heat pump equipment is provided in Chapter 4.1, *Description of Baseline Unit*.

2.3.3 Technology Screening

An initial list of efficiency enhancement options is developed from the technologies identified in the technology assessment. Then the Department, in consultation with interested parties, reviews the list to determine if they are practicable to manufacture, install and service, would adversely affect product utility or product availability, or would have adverse impacts on health and safety. Efficiency enhancement options not eliminated in the screening process are considered further in the Engineering Analysis. Chapter 3 discusses which conventional technologies were considered in the central air conditioner and heat pump Engineering Analysis. Also included is a list of emerging technologies which could impact future central air conditioner and heat pump manufacturing costs.

2.4 ENGINEERING ANALYSIS

As presented in Chapter 4, the engineering analysis determines the maximum technologically feasible energy efficiency level and develops cost-efficiency relationships to show the manufacturer costs of achieving increased efficiency. The engineering analysis conducted for the Supplemental ANOPR was revised and updated for this TSD.

2.4.1 Efficiency Improvement Potential

In general, the engineering analysis estimates the efficiency improvement potential of the individual or combinations of design options not eliminated in the previous screening analysis. The Department, in consultation with stakeholders, uses the most appropriate means available to determine energy consumption, including an overall system approach or engineering modeling. Ranges and uncertainties in performance are established. The energy savings measures developed in the engineering analysis are combined with end-user costs in the LCC analysis.

The engineering analysis involves adding individual or combinations of design options to the baseline unit. A cost-efficiency relationship is developed to show the manufacturer cost of achieving increased efficiency. The efficiency levels corresponding to various design option combinations are determined from manufacturer data submittals and from DOE engineering calculations.

As described in Chapter 1, the Act requires that the Department design any new or amended standard “to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified." EPCA, §325(o)(2)(A), 42 U.S.C. §6295(o)(2)(A). The Act also requires the Department, in a proposed rule that sets forth new or amended standards, to “determine the maximum improvement in energy efficiency... that is technologically feasible for each type (or class) of covered products....” EPCA Section 325 (p)(2), 42 U.S.C. 6295(p)(2). Therefore an essential role of the engineering analysis consists of identifying the maximum technologically feasible level. The maximum technologically feasible level is one that can be reached by the addition of efficiency improvements and/or design options, both commercially feasible and in prototypes, to the baseline units. The Department believes that the design options comprising the maximum technologically feasible level must have been physically demonstrated in at least a prototype form to be considered technologically feasible.

In general, three methodologies can be used to generate the manufacturing costs needed for the engineering analysis. These methods include: 1) the design-option approach, reporting the incremental costs of adding design options to a baseline model; 2) the efficiency-level approach, reporting relative costs of achieving energy efficiency improvements; 3) and the reverse engineering or cost-assessment approach which requires a "bottoms-up" manufacturing cost assessment based on a detailed bill of materials. The Department considers public comments in determining the best approach for a rulemaking.

If the efficiency-level approach is used, the Department will select appropriate efficiency levels for data collection on the basis of: 1) energy savings potential identified from engineering models; 2) observation of existing products on the market; and/or 3) information obtained for the technology assessment. Stakeholders will be consulted on the efficiency level selection.

The use of a design-option approach provides useful information such as the identification of potential technological paths manufacturers could use to achieve increased product energy efficiency. It also allows the use of engineering models to simulate the energy consumption of different design configurations under various user profiles and applications. However, the Department recognizes that the manufacturer cost information derived in the design-option approach does not reflect the variability in design strategies and cost structures that can exist between manufacturers. Therefore, the Department may derive additional manufacturing cost estimates from other approaches developed in consultation with interested parties.

The reverse engineering or cost-assessment approach can be used to supplement the efficiency-level or design option approaches under special circumstances when data is not publically available because of proprietary reasons, the product is a prototype, and/or the data is not provided by the manufacturers.

In the rulemaking for central air conditioners and heat pumps, the Department selected the efficiency level approach as the primary method for conducting the engineering analysis. The Department also decided to utilize a reverse engineering approach as a “stand alone” analysis for developing manufacturer costs and validating the costs developed through the efficiency level approach. Both approaches are discussed in detail in Chapter 4.

2.4.1.1 Efficiency-Level Approach

The efficiency-level approach establishes the relationship between manufacturer cost and increased efficiency at incremental increases in efficiency levels. This method has the distinct advantage of being simple and straight forward. Manufacturers typically provide incremental manufacturer cost data for incremental increases in efficiency. Cost-efficiency curves can be easily constructed to clearly identify at what point manufacturers are incurring significant costs to raise efficiency. Additionally, the efficiency-level approach allows manufacturers the ability to supply detailed cost data without revealing their unique design strategies for achieving increased efficiency levels.

But the simplicity of the efficiency-level approach is also its primary drawback. Namely, since technological details are not provided, it is extremely difficult to verify whether the costs provided for each specific efficiency level are truly representative of the costs for that level. In addition, prototypical designs become difficult to evaluate and maximum technologically feasible designs are then difficult to ascertain. As a result, some other type of analysis is likely needed in order to verify the accuracy of the costs supplied through the efficiency level approach.

2.4.1.2 Reverse Engineering Approach

As discussed above, the efficiency level approach requires verification of the data submitted. The use of a component-based technology-costing (reverse engineering) approach identifies potential technological paths manufacturers typically use to achieve increased product energy efficiency. Under this type of analysis, actual equipment on the market are physically analyzed, i.e., dismantled, component-by-component to determine what technologies and designs manufacturers employ to increase efficiency. Independent costing methods and manufacturer and component supplier data are then used to estimate the costs of the components. This approach has the distinct advantage of using "real" market equipment to establish the technologies that are used by manufacturers and to establish the manufacturing cost to produce more efficient units.

The primary disadvantage of reverse engineering is the time and effort required to analyze "real" equipment. Several models from a diverse range of manufacturers may have to be assessed in order to ensure that an accurate representation of technological paths for increasing efficiency are identified. In addition, since only equipment in the market is analyzed, prototypical designs may not be captured by the analysis, thus making it difficult to establish maximum technologically feasible designs.

2.4.1.3 Design Option Approach

The design option approach identifies individual or combinations of design options which increase efficiency. Design option efficiency increases can either be based on manufacturer or component supplier estimates or through the use of engineering computer simulation models. The incremental manufacturing costs of adding design options to a baseline model are then established. Individual or combinations of design options are added to the baseline model in ascending order of cost-effectiveness. Typically, the payback period is used to establish a design option's cost-effectiveness and is determined by the ratio of the change in total consumer cost to the change in operating cost.

The primary advantage of the design option approach is its ability to analyze individual technologies. The approach is transparent in that the impact of any single technology on cost and efficiency is explicit. An additional advantage is its ability to incorporate designs that have been demonstrated to perform in prototypes but have yet to be utilized in equipment currently available on the market. Thus, maximum technologically feasible designs are more easily established then in the efficiency level approach.

Although individual technologies can be assessed, the design option approach can tend to be complex. Individual technologies may be combined in ways not typically utilized by manufacturers, especially if prototypical technologies are being analyzed, thus, making it difficult to assess a design's impact on system cost and efficiency. In order to determine a technology's impact on system efficiency, computer simulation models are typically employed. But since computer simulation models exhibit at least some level of inaccuracy, a great deal of time and effort must be expended to validate the model's results at a variety of operating conditions. Simulation models demand detailed input that may require manufacturers and component suppliers to reveal proprietary design strategies. Also, equipment performance data at specified test conditions must be supplied in order to validate the model's performance.

Another drawback to the design option approach is its imperfect compatibility with the manufacturing impact analysis. The Department recognizes that the manufacturer cost information derived in a component-based analysis does not reflect the variability in baseline units, design strategies and cost structures that can exist between manufacturers. Therefore, for the manufacturing impact analysis, the Department may need to derive additional manufacturing cost estimates, using other approaches developed in consultation with interested parties.

2.4.1.4 Outside Regulatory Changes affecting the Engineering Analysis

In conducting an engineering analysis, there sometimes occur regulatory changes outside of the NAECA efficiency standards process that can impact the manufacture of the product. Some of these changes can also affect the efficiency of the product as well. The Department attempts to identify all "outside" issues that can impact the engineering analysis. A current regulatory change affecting central air conditioners and heat pumps is the discontinued use of HCFC refrigerants. Chapter 4.7, *Alternative Refrigerants*, provides more detailed information on this topic.

2.4.2 Manufacturer Costs

Manufacturing costs are used as the means of determining retail prices, and are needed for the manufacturer impact analysis. Manufacturing costs for central air conditioners and heat pumps are described in detail in Chapter 4.2, *Manufacturing Costs*.

2.4.2.1 Characterizing Uncertainty

Consistent with the process rule, DOE places a range around the average manufacturing costs of achieving various efficiency levels. The ranges of costs are used to generate retail prices for the consumer life-cycle cost analysis, and are used in the industry cashflow analysis.

2.4.2.2 Variability in Costs between Manufacturers

The Department is committed to assessing the differential impacts of standards on different manufacturers. The results are used as inputs for the sub-group analysis of manufacturing impacts, which entails calculating cashflows separately for each class of manufacturer.

2.4.2.3 Proprietary Design

In general, the Department considers in its analysis all design options that are commercially available or present in a working prototype, including proprietary designs. Proprietary designs are fully considered in the Department's engineering and economic analyses. For this rulemaking, engineering and economic analyses were limited to equipment currently in the market.

2.5 LIFE-CYCLE COST (LCC) AND PAYBACK ANALYSIS

As will be presented in Chapter 5, the Life-Cycle Cost and Payback Period Analysis calculates the discounted savings in operating costs (less maintenance and repair costs) throughout the estimated average life of the covered product compared to any increase in the installed cost for the product likely to result directly from the imposition of a standard. The life-cycle cost and payback period analysis conducted for the Supplemental ANOPR was revised and updated for this TSD. In determining economic justification, the Act directs the Department to consider a number of different factors, including the economic impact of potential standards on consumers. The Act also establishes a rebuttable presumption that a standard is economically justified if the additional product costs attributed to the standard are less than three times the value of the first year energy cost savings that the consumer will receive as a result of the standard. EPCA, §325(o)(2)(B)(iii), 42 U.S.C. §6295 (o)(2)(B)(iii).

To consider these requirements the Department calculates changes in LCC to the consumers that are likely to result from the proposed standard as well as two different simple payback periods: a payback period based on probability distributions, and a payback period based on single-point values and test procedure assumptions which is known as "the rebuttable presumption" payback. The effect of standards on individual consumers includes a change in operating expense (usually decreased) and a change in purchase price (usually increased). The net effect is analyzed by calculating the change in LCC as compared to the base case. Inputs to the LCC calculation include the installed consumer cost (purchase price plus installation cost), operating expenses (energy, repair, and maintenance costs), lifetime of the appliance, and a discount rate.

2.5.1 LCC Spreadsheet Model

The LCC analysis is conducted using a spreadsheet model developed in Microsoft Excel combined with Crystal Ball (a commercially available software program). The Model uses a Monte Carlo simulation described in Appendix A to perform the analysis, considering uncertainty and variability. The LCC spreadsheet is organized so that ranges (or probability distributions) can be entered for each input variable needed to perform the calculations.

Based on the results of the LCC analysis, DOE selects candidate standard levels for a more detailed analysis. The range of candidate standard levels typically includes: (1) the most energy-efficient combination of design options or most energy-efficient level equipment available in the market; (2) the combination of design options or efficiency levels with the lowest LCC; and (3) the combination of design options or efficiency levels with a payback period of not more than three years. Additionally, candidate standard levels that incorporate noteworthy technologies or fill in large gaps between efficiency levels of other candidate standards levels may be selected.

Payback is calculated based on the same inputs used for the LCC analysis (with the difference that the values are based only on the first year the standard takes affect). The output is a probability distribution of payback periods, including the mean and median payback period as well as the minimum and maximum payback periods. Additional information is available in the LCC spreadsheet available on the DOE website.

The payback for purposes of the rebuttable presumption clause is calculated on the LCC spreadsheet using single-point values rather than probability distributions. For central air conditioners and heat pumps, payback periods are first calculated based on differences between equipment designed for a new standard level and equipment typical of that being sold in the year 2006. The paybacks are then weighted and averaged according to the percentage of each equipment efficiency sold before a new standard is enacted. Input values such as the annual operational hours per year will correspond to those outlined in the DOE test procedure. The payback is calculated for the expected effective year of the standard (e.g., 2006).

2.5.2 Equipment Prices

Equipment prices are needed for a base case, absent new standards, and for all efficiency levels to be considered. Several approaches can be used to obtain these retail prices. Potential approaches include: 1) conducting a survey of existing prices on the market; 2) surveying manufacturers and other market experts to predict consumer willingness to pay higher prices; and 3) applying various mark-ups over manufacturing costs. Consistent with the Process Rule, and building on the estimates generated by various approaches, retail prices would be described within a range of uncertainty.

Chapter 4.3, *Distribution Markups,* and Appendix D provide a detailed description of the approach used for determining industry-average prices and mark-ups for central air conditioners and heat pumps. Manufacturer and retail or equipment prices are needed to determine how manufacturing costs and associated margins, associated with standards, are passed-through from manufacturers to consumers, as this has an impact on both consumers and manufacturers. Consumer and manufacturer economics are linked and inversely related. For this reason, retail prices used for the LCC analysis need to be reconciled with manufacturer prices.

2.6 PRELIMINARY NATIONAL IMPACTS ANALYSIS

As discussed in Chapter 7, the national impacts analysis assesses the net present value (NPV) of total consumer LCC, energy savings and indirect employment impacts. A preliminary assessment of the aggregate impacts at the national level was conducted for the Supplemental ANOPR. The national impacts analysis was revised and updated for this TSD. Analyzing impacts of Federal energy-efficiency standards requires a comparison of projected U.S. residential energy consumption with and without standards. The base case, which is the projected US residential energy consumption without standards, includes the mix of efficiencies being sold at the time the standard becomes effective.

As discussed in Chapter 6, sales projections together with efficiency levels of the central air conditioners and heat pumps are important inputs to determine the energy consumption for the Nation as a whole under both base case and standards case scenarios. The differences between the base case and standards case provides the energy and cost savings. Depending on the analysis method used, the sales under a standards case projection may differ from those under a base case projection.

The Department estimates national energy consumption for each year beginning with the expected effective date of the standards. National annual energy savings are calculated as the difference between two projections: a base case and a standards case. Analysis includes estimated energy savings by fuel type used for generating electricity. Energy consumption and savings are estimated based on site energy (kWh of electricity), then the electricity consumption and savings are converted to source energy.

Measures of impact reported include the net present value (NPV) of total consumer LCC, national energy savings, and indirect employment impacts. Each of the above are determined for selected trial standard levels. These calculations are done by the use of a spreadsheet tool called the National Energy Savings (NES) Spreadsheet Model, which has been developed for all the standard rulemakings and tailored to each specific appliance rulemaking.

2.6.1 National Energy Savings (NES) Spreadsheet Model

In order to make the analysis more accessible and transparent to all stakeholders, a spreadsheet model was developed using Microsoft Excel to calculate the national energy savings and the national economic costs and savings from new standards. Input quantities can be changed within the spreadsheet. Unlike the LCC analysis, in the NES Spreadsheet, distributions are not used for inputs or outputs. Sensitivities can be demonstrated by running different scenarios. The NES spreadsheet model is available on the DOE website.

2.6.2 Shipments

One of the more important components of any estimate of future impacts is shipments. Forecasts of shipments for the base case and the standard case need to be obtained as an input to the NES. The Department chose an accounting model method to prepare shipment scenarios for the base case and several standard cases. Basically, the model keeps track of the stocks and purchases of each type of central air conditioner and heat pump. Events and consumer decisions influence how the stock and supply of central air conditioner and heat pump systems flow from one category to another. Decisions that are economically influenced are modeled with econometric equations.

The model is organized into three classes of elements: stocks, events, and decisions. Stocks of central air conditioners and heat pumps are divided into *ownership categories*, and units are assigned to age categories. Events are things that happen to stocks independent of economic conditions, i.e., breakdowns requiring repair or replacement. Decisions are consumer reactions to market conditions, e.g., whether to repair or replace equipment, or buy a house with or without a central air conditioner or heat pump. Purchase decisions are categorized by *market segments*. Decision trees are used to describe consumer choices for purchases and repairs. A *logit probability model* simulates consumer purchase decisions that based on equipment price, operating costs, and income level. Chapter 6 provides a detailed description of how shipments forecast were conducted.

2.6.3 Net National Employment Impacts

The Process Rule calls for employment impacts to be considered in selecting a proposed standard. The Department will estimate the impacts of standards on employment for air conditioner and heat pump manufacturers, relevant service industries, energy suppliers, and the economy in general. Employment impacts are separated into indirect and direct impacts. Direct employment impacts would result if standards lead to a change in the number of employees at manufacturing plants and related supply and service firms. Direct impacts are discussed in Chapter 8 on the manufacturer impact analysis. Net national employment impacts are impacts on the national economy other than in the manufacturing sector being regulated. Net national employment impacts may result from both expenditures shifting among goods (substitution effect), and income changing, which will lead to a change in overall expenditure levels (income effect).

Net national employment impacts from standards are defined as net jobs eliminated or created in the general economy as a consequence of increased spending to purchase central air conditioners and heat pumps and reduced spending to pay utility costs. New equipment standards are expected to increase the purchase price, which includes retail price, sales tax and installation. The same standards are also expected to decrease energy consumption, and therefore reduce household expenditures for energy. Over time, the increased purchase price may be paid back through energy savings. The savings in energy expenditures may be spent on other items. Using an input/output model of the U.S. economy, this analysis seeks to estimate the effects on different sectors, and the net impact on jobs. National impacts have been estimated for major sectors of the U.S. economy for this TSD. Public and commercially available data sources and software have been utilized to estimate employment impacts. All methods and documentation are provided in Chapter 12.

2.7 CONSUMER ANALYSIS

Chapter 10 describes the consumer sub-group analysis which evaluates impacts to consumers with low-income levels, who may be disproportionately affected by any national energy efficiency standard level.

In evaluating consumers with low-income levels, the Department has evaluated variations in regional energy prices, variations in energy use and variations in installation costs that affect the net present value of a standard. DOE obtains estimates of the variability in each input quantity and considers this variability in its calculation of consumer impacts.

Variations in energy use for a particular appliance can depend on factors such as: climate, type of household, number of people in household, etc. Annual energy use can be estimated by a calculation based on an accepted test procedure or it can be measured directly in the field. The Department performs sensitivity analyses to consider how differences in energy use will affect sub-groups of consumers. The impact on low-income consumer sub-groups has been determined using the LCC spreadsheet model.

2.7.1 Purchase Price Increases

The Department has been sensitive to purchase price increases to avoid negative impacts to low-income households. Additionally, the Department has assessed the likely impacts of purchase price increases on product sales.

2.7.2 Consumer Participation

The Department seeks to inform and involve consumers and consumer representatives in the process of developing standards. This includes notification of consumer representatives during the rulemaking process and where appropriate, seeking direct consumer input.

2.8 MANUFACTURER IMPACT ANALYSIS

Chapter 8 describes the manufacturer impact analysis (MIA). This analysis estimates the financial impact of standards on manufacturers and also calculates the impact of standards on competition, employment, and manufacturing capacity.

Prior to initiating the detailed MIA, the Department prepared an approach document and made it available for review. The Department tailored the methodology for central air conditioners and heat pumps on the basis of stakeholder comments. The document outlines procedural steps and outlines issues for consideration. Three important elements of the approach consist of the preparation of an industry cash flow, the development of a process to consider sub-group cash flow, and the design of a guide to interview manufacturers and others in gathering information.

The policies outlined in the Process Rule required substantial revisions to the analytical framework to be used in performing manufacturer impact analysis for each rulemaking. In the approach document, the Department describes and obtains comments on the methodology to be used in performing the manufacturer impact analyses. The manufacturer impact analyses was conducted in three phases (see Figure 2.2). Phase 1 consisted of two activities, namely, preparation of an industry characterization and identification of issues. The second phase was focused on the larger industry. In this phase, the Government Regulatory Impact Model (GRIM) has been used to perform an industry cash flow analysis. Phase 3 involves repeating the process described in Phase 2 (the industry cash-flow analysis) but on different sub-groups of manufacturers. Phase 3 also entails calculating additional impacts on competition, employment, and manufacturing capacity.

2.8.1 Industry Characterization

Phase 1 of the MIA consists of collecting pertinent financial and market information. This activity involves both quantitative and qualitative efforts. Data gathered included market share, corporate operating ratios, wages, employment, and production cost ratios. These data are incorporated into the Engineering Analysis in the estimation of equipment production costs and distribution markups. Sources of information include reports published by industry groups, trade journals, and the U.S. Bureau of Census, and copies of SEC 10-K filings.

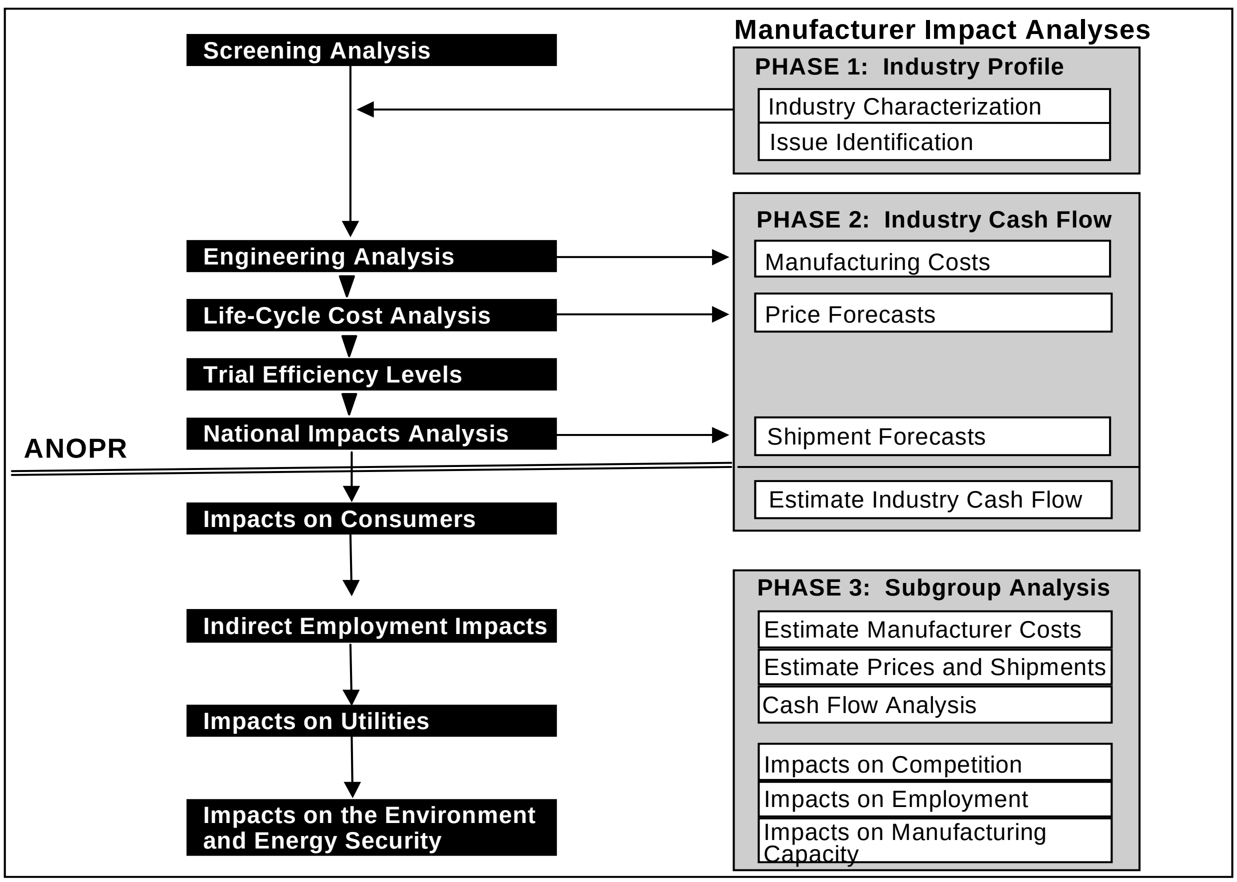

Figure 2.2 Flow diagram of the manufacturer impact analysis methodology

2.8.2 Industry Cash Flow

Increased efficiency standards affect manufacturers in three distinct ways, by (1) requiring additional investment; (2) by raising production costs, and (3) by affecting revenue because of higher prices and, possibly, lower quantities sold. To quantify these changes the Department performs an industry cash flow analysis using the Government Regulatory Impact Model (GRIM). Usually this analysis will use manufacturing costs, shipments forecasts, and price forecasts developed for the LCC and NES analyses. Financial information, also required as an input to GRIM, has been developed based on publicly available data and manufacturer information confidentially submitted to the Department's contractor, Arthur D. Little, Inc .

The GRIM analysis uses a number of factors—annual expected revenues; manufacturer costs such as cost of sales, selling and general administration costs, taxes, and capital expenditures related to depreciation, new standards, and maintenance—to arrive at a series of annual cash flows beginning from before implementation of standards and continuing explicitly for several years after implementation. The measure of industry net present values are calculated by discounting the annual cash flows from the period before implementation of standards to some future point in time. Appendix G provides a description of GRIM's operating principles.

2.8.3 Manufacturer Sub-Group Analysis

Assessment of impacts on sub-groups of manufacturers is Phase 3 of the MIA. Using industry "average" cost values is not adequate for assessing the variation in impacts among sub-groups of manufacturers. Smaller manufacturers, niche manufacturers or manufacturers exhibiting a cost structure largely different from industry averages could be more negatively affected. Ideally, the Department would consider the impact on every firm individually. In highly concentrated industries this may be possible. In industries having numerous participants, the Department will use the results of the industry characterization to group manufacturers exhibiting similar characteristics. The financial analysis of the "prototypical" firm performed in the Phase 2 industry analysis can serve as a benchmark against which manufacturer sub-groups can be analyzed.

The manufacturing cost data collected for the engineering analysis has been used to the extent practical in the sub-group impact analysis. To be useful, however, this data has been disaggregated to reflect the variability in costs between relevant sub-groups of firms.

The Department has conducted detailed interviews with as many manufacturers as is possible to gain insight into the potential impacts of standards. During these interviews, the Department has gathered the information necessary to evaluate cashflows and to assess competitive, employment and capacity impacts. Firm-specific cumulative burden has been considered.

2.8.4 Interview Process

The revised rulemaking process provides for greater public input and for improved analytical approaches, with particular emphasis on earlier and more extensive information gathering from interested parties. The three-phase manufacturer impact analysis process draws on multiple information sources, including structured interviews with manufacturers and a broad cross-section of interested parties. Interviews were conducted in most phases of the analyses as determined in Phase 1 of the MIA.

The interview process was a key role in the manufacturer impact analyses, since it provides an opportunity for manufacturers to privately express their views on important issues. A key characteristic of the interview process is that it is designed to allow confidential information to be considered in the rulemaking process.

The industry characterization collects information from relevant industry and market publications, industry trade organizations, company financial reports, and product literature. This information aids in the development of detailed and focused questionnaires, as needed, to perform all phases of the manufacturer impact analyses.

The Phase 3 (sub-group analysis) questionnaire solicits information on the possible impacts of potential efficiency levels on manufacturing costs, product prices, and sales. Evaluation of the possible impacts on direct employment, capital assets, and industry competitiveness will also draw heavily on the information gathered during the interviews. The questionnaires solicits both qualitative and quantitative information. Supporting information will be requested whenever applicable.

Interview participants were requested to identify all confidential information provided in writing or orally. Approximately two weeks following the interview, an interview summary was provided to give participants the opportunity to confirm the accuracy and protect the confidentiality of all collected information. All the information transmitted was considered, when appropriate, in DOE's decision-making process. However, confidential information will not be made available in the public record.

DOE has collated the completed interview questionnaires and prepared a summary of the major issues and outcomes.

2.9 COMPETITIVE IMPACT ASSESSMENT

Legislation directs the Department to consider any lessening of competition that is likely to result from standards. It further directs the Attorney General to gauge the impacts, if any, of any lessening of competition. DOE has made an effort to gather and report firm-specific financial information and impacts. The competitive analysis, as discussed in Chapter 9, focuses on assessing the impacts to smaller, yet significant, manufacturers. The assessment is based on manufacturing cost data and on information collected from interviews with manufacturers, consistent with Phase

3 of the MIA. The Department of Justice (DOJ) has helped in drafting questions to be used in the manufacturer interviews. These questions pertain to the assessment of the likelihood of increases in market concentration levels and other market conditions that could lead to anti-competitive pricing behavior. The manufacturer interviews have focused on gathering information that helps in assessing asymmetrical cost increases to some manufacturers, increased proportion of fixed costs potentially increasing business risks, and potential barriers to market entry (proprietary technologies, etc.).

2.10 UTILITY ANALYSIS

The utility analysis estimates the effects of proposed standards on electric and gas utilities.

The Department uses a version of Energy Information Administration's (EIA) widely recognized National Energy Modeling System (NEMS) for the utility and environmental analyses. NEMS is a large multi-sectoral partial equilibrium model of the U.S. energy sector that has been developed over several years by the EIA, primarily for the purpose of preparing the Annual Energy Outlook (AEO). NEMS produces a widely recognized baseline forecast for the U.S. through 2020 and is available in the public domain. The version of NEMS to be used for appliance standards analysis will be called NEMS-BRS, together with some exogenous calculations.[a]

Forecasting for the electric utility industry is seriously complicated by the implications of industry restructuring, which is only partially reflected in the latest *AEO* (2000).

To analyze the effect of standards, NEMS-BRS is first run exactly as it would be to produce an AEO forecast, then a second run is conducted with residential energy usage reduced by the amount of energy (gas, oil, and electricity) saved due to appliance standards for the appliance being analyzed. The energy savings input is obtained from the NES spreadsheet. Outputs available are the same as those in the original NEMS model including residential energy prices, generation and installed capacity (and in the case of electricity, which primary fuel is used for generation).

2.11 ENVIRONMENTAL ANALYSIS

The Department is preparing an Environmental Assessment of the impacts of the proposed rule and DOE anticipates completing a Finding of No Significant Impact (FONSI) before publishing the final rule on Energy Conservation Standards for central air conditioners and heat pumps,

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[a] For more information on NEMS, please refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 1998*, DOE/EIA-0581(98), February, 1998. DOE/EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because our analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on DOE/EIA assumptions, the name NEMS-BRS refers to the model as used here (BRS is DOE's Building Research and Standards office, under whose aegis this work has been performed.

pursuant to the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 et seq.), the regulations of the Council on Environmental Quality (40 CFR Parts 1500-1508), and the Department's regulations for compliance with NEPA (10 CFR Part 1021).

The main environmental concern addressed is emissions from fossil fuel-fired electricity generation. Power plant emissions include oxides of nitrogen (NOx) and sulfur (SO_2), as well as carbon dioxide (CO_2). The first two are major causes of acid precipitation, which can affect humans by reducing the productivity of farms, forests and fisheries, decreasing recreational opportunities and degrading susceptible buildings and monuments. NOx is also a precursor gas to urban smog and is particularly detrimental to air quality during hot, still weather. CO_2 emissions are believed to contribute to raising the global temperature via the "greenhouse effect." The long-term consequences of higher temperatures may include perturbed air and ocean currents, perturbed precipitation patterns, changes in the gaseous equilibrium between the atmosphere and the biosphere, and the melting of some of the ice now covering polar lands and oceans, causing a rise in sea level.

The Department uses EIA's widely recognized NEMS for the appliance environmental analyses. The version of NEMS to be used for appliance standards analysis will be called NEMS-BRS, and will be based on the AEO99 version with minor modifications. NEMS-BRS is run exactly the same as the original NEMS except that residential energy usage is reduced by the amount of energy (gas, oil, and electricity) saved due to appliance standards for the appliance being analyzed. The input of energy savings are obtained from the NES spreadsheet. For the environmental analysis, the output is the forecasted physical emissions. The net benefits of a standard will be the difference between emissions estimated by the *AEO2000* version of NEMS-BRS and those it estimates with a standard in place.

2.12 REGULATORY IMPACT ANALYSIS

DOE has prepared a draft regulatory analysis pursuant to E.O. 12866, "Regulatory Planning and Review," which will be subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA)58 FR 51735 (October 4, 1993). Eleven major alternatives were identified by DOE as representing feasible policy options to achieve consumer product energy efficiency. Each alternative has been evaluated in terms of ability to achieve significant energy savings at a reasonable cost and will be compared to the effectiveness of the rule.

Under the Process Rule policies, the Department is committed to continually explore non-regulatory alternatives to standards. Table 2.1 discusses the alternatives analyzed for this rulemaking.

Table 2.1 Non-Regulatory Alternatives to Standards

Alternatives Examined
-No new regulatory action
-Consumer product labeling
-Public Education
-Prescriptive Standards
-Consumer tax credits
-Manufacturer tax credits
-Consumer Rebates
-Low Income Subsidy
-Voluntary energy efficiency targets
-Mass Government purchases
-Early Replacement